

Vomiting in Infants Up to 3 Months of Age
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Stinger DA, Babyn PS, eds. <i>Pediatric Gastrointestinal Imaging and Intervention</i> . 2nd ed. Hamilton, Ontario, Canada: Decker; 2000.	Review/Other-Dx	N/A	Book chapter.	N/A	4
2. Hilton S. The child vomiting. In: Hilton S, Edwards D, eds. <i>Practical Pediatric Radiology</i> . Philadelphia, Pa.: BC Decker; 1994:297-299.	Review/Other-Dx	N/A	Book chapter.	N/A	4
3. Ryan S, Donoghue V. Gastrointestinal pathology in neonates: new imaging strategies. <i>Pediatr Radiol</i> . 2010;40(6):927-931.	Review/Other-Dx	N/A	Review new imaging strategies for imaging gastrointestinal pathology in the premature infant. Review also addresses how antenatal diagnosis of gastrointestinal tract abnormalities has changed the imaging strategy and management of the neonate.	New imaging strategies and alternative modalities of imaging include US, CT, MRI and radionuclide studies.	4
4. Hernanz-Schulman M. Imaging of neonatal gastrointestinal obstruction. <i>Radiol Clin North Am</i> . 1999;37(6):1163-1186, vi-vii.	Review/Other-Dx	N/A	Review the various origins of gastrointestinal obstruction in the newborn infant in a progressive fashion, from the gastric outlet to the colon.	Study emphasizes the contribution of the radiologist in diagnosis and nonsurgical treatment and outlines the role of plain films, sonography, and contrast studies.	4
5. Lilien LD, Srinivasan G, Pyati SP, Yeh TF, Pildes RS. Green vomiting in the first 72 hours in normal infants. <i>Am J Dis Child</i> . 1986;140(7):662-664.	Observational-Dx	45 total newborns: 9 had surgical intervention, 5 had nonsurgical obstruction 31 had idiopathic bilious vomiting	To note causes of green vomiting in neonate in the first 72 hours. Newborns were prospectively followed-up.	Infants with idiopathic bilious vomiting had a benign transient course and resumed feedings by 1 week of age; 30/31 had normal or nonspecific findings on initial plain abdominal roentgenogram. Specific findings on the initial plain abdominal roentgenogram were noted in 5 infants, and 4 (80%) of these had a lesion requiring surgical intervention; 56% (5/9) of neonates with surgical lesions had normal or nonspecific findings on the plain abdominal roentgenograms. None developed bowel ischemia or midgut infarction secondary to a volvulus as they were identified by contrast studies shortly after the initial episode of bilious vomiting. Although the majority of "normal" neonates with bilious vomiting do not have a surgical lesion, this study indicates that 56% of surgical cases will be missed if contrast studies are not done.	4
6. Strouse PJ. Disorders of intestinal rotation and fixation ("malrotation"). <i>Pediatr Radiol</i> . 2004;34(11):837-851.	Review/Other-Dx	N/A	Radiologic findings of malrotation and volvulus are reviewed and illustrated with particular attention to the child with equivocal imaging findings.	Prompt radiological diagnosis is critical for children with this condition.	4

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7. Sizemore AW, Rabbani KZ, Ladd A, Applegate KE. Diagnostic performance of the upper gastrointestinal series in the evaluation of children with clinically suspected malrotation. <i>Pediatr Radiol</i> 2008; 38(5):518-528.	Observational-Dx	166 patients	To determine the diagnostic performance of UGI examinations in children who subsequently underwent a Ladd procedure for suspected malrotation or volvulus.	Of 163 patients with surgically verified malrotation, 156 had a positive UGI examination, a sensitivity of 96%. Jejunal position can lead to inaccurate UGI series interpretation. Meticulous technique and periodic assessment of performance will help more accurately diagnose difficult or equivocal cases.	2
8. Hsiao M, Langer JC. Value of laparoscopy in children with a suspected rotation abnormality on imaging. <i>J Pediatr Surg</i> . 2011;46(7):1347-1352	Observational-Dx	51 patients	To study the utility of laparoscopy in the management of children with a suspected rotation abnormality on imaging.	There were 51 patients. Preoperative diagnosis based on UGI contrast study with or without contrast enema or US was malrotation without volvulus in 47%, malrotation with volvulus in 10%, and nonrotation in 6%; the other 37% had equivocal or inconclusive imaging studies. Of the patients who had a "definitive" preoperative diagnosis, 41% had a discrepant finding at laparoscopy. For those with inconclusive imaging studies, 32% were found on laparoscopy to have a narrow mesenteric base, which put them at significant risk of midgut volvulus.	3
9. Long FR, Kramer SS, Markowitz RI, Taylor GE, Liacouras CA. Intestinal malrotation in children: tutorial on radiographic diagnosis in difficult cases. <i>Radiology</i> . 1996;198(3):775-780.	Review/Other-Dx	81 symptomatic children	To analyze difficult diagnostic cases of malrotation to identify features crucial to accurate diagnosis.	Subtle signs of malrotation included unusual redundancy of the duodenum to the right of the spine and location of the duodenojejunal junction medial to the left pedicle. Nevertheless, 2 children with variations of malrotation had normal UGI examinations. False-positive diagnoses resulted from failure to recognize normal variants: jejunum in the right upper quadrant as the sole finding, duodenojejunal junction over the left pedicle on the anteroposterior view, "duodenum inversum," and "duodenum mobile." Three children had bowel distention that displaced the duodenojejunal junction.	4

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10. Cribbs RK, Gow KW, Wulkan ML. Gastric volvulus in infants and children. <i>Pediatrics</i> . 2008;122(3):e752-762.	Review/Other-Dx	7 cases from authors institution 581 published cases (252 acute and 329 chronic cases)	To review diagnosis and treatment of gastric volvulus, report 7 additional cases, and present common features seen in pediatric patients with gastric volvulus to increase understanding of this condition.	Most common presentation of acute gastric volvulus is in a child <5 years old with nonbilious emesis, epigastric distention, and abdominal pain. Acute gastric volvulus is often associated with deformities of adjacent organs. Most common presentation of chronic volvulus is in an infant <1 year old with emesis, epigastric distention, feeding difficulties, and growth failure. Treatment may be medical or surgical depending on the underlying etiology of the volvulus.	4
11. Lederman HM, Demarchi G. Disorders of the Esophagogastric Junction. In: Slovis TA, ed. <i>Caffey's Pediatric Diagnostic Imaging</i> . 11th ed. St Louis, Mo: Mosby/Elsevier Science; 2008:2042-2055.	Review/Other-Dx	N/A	Book chapter.	N/A	4
12. Orzech N, Navarro OM, Langer JC. Is ultrasonography a good screening test for intestinal malrotation? <i>J Pediatr Surg</i> . 2006;41(5):1005-1009.	Observational-Dx	211 patients	Review children undergoing UGI and US to determine the accuracy of US in screening for intestinal malrotation.	Among abnormal US, inversion of SMA/SMV and a “whirlpool” sign were more predictive for malrotation and volvulus than anterior/posterior orientation. US is a good screening tool that effectively rules out malrotation at risk for volvulus. Children with an abnormal US should have an UGI or go to the operating room, depending on clinical findings.	3
13. Weinberger E, Winters WD, Liddell RM, Rosenbaum DM, Krauter D. Sonographic diagnosis of intestinal malrotation in infants: importance of the relative positions of the superior mesenteric vein and artery. <i>AJR</i> 1992; 159(4):825-828.	Observational-Dx	337 infants	Retrospective review of vomiting infants referred to rule out hypertrophic pyloric to determine position of superior mesenteric vessels (nonbilious).	Relative positions of the SMV and artery were evident in 249 (74%) of patients. Abnormal orientation of the mesenteric vessels was detected in 9 patients. In 5 patients, the SMV was located to the left of the artery, and all 5 had intestinal malrotation. In 4 patients, the SMV was directly ventral to the artery, and one of these had malrotation. US assessment of the relative positions of the mesenteric artery and vein is an important adjunct in the examination of infants with suspected pyloric stenosis.	3

Vomiting in Infants Up to 3 Months of Age
EVIDENCE TABLE

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14. Menten R, Reding R, Godding V, Dumitriu D, Clapuyt P. Sonographic assessment of the retroperitoneal position of the third portion of the duodenum: an indicator of normal intestinal rotation. <i>Pediatr Radiol.</i> 2012;42(8):941-945.	Review/Other-Dx	85 children	To demonstrate the agreement between UGI and US in assessing the position of the third portion of the duodenum and to show that a retroperitoneal duodenum indicates normal forgut rotation.	85 children, 5 months to 14 years old, were studied. In 82/85 (96%), both US and UGI suggested normal forgut rotation. In 3 children, US demonstrated a normal position of the third portion of the duodenum, whereas UGI showed an abnormal position of the duodenojejunal junction.	4
15. Karmazyn B. Duodenum between the aorta and the SMA does not exclude malrotation. <i>Pediatr Radiol.</i> 2013;43(1):121-122.	Review/Other-Dx	N/A	Letter.	N/A	4
16. De Giacomo C, Maggiore G, Fiori P, et al. Chronic gastric torsion in infancy: a revisited diagnosis. <i>Australas Radiol.</i> 1989;33(3):252-254.	Observational-Dx	20 infants	To examine clinical, radiologic and laboratory findings of infants who had UGI X-ray study during a period of 2 years.	20 had peculiar shape and position of stomach due to chronic gastric torsion. Other cases of recurrent vomiting GER, extraintestinal causes, and nutritional abnormalities. Be wary of sudden episode of cyanosis and apnea, anorexia or pneumonia in association with recurrent vomiting as possible indicator of the entity. Diagnosis frequently suspected on radiographs via transverse position of stomach. Gastric volvulus is not uncommon. Frequently associated with GER. Cyanosis, failure to thrive, esophagitis sideropenic anemia.	3
17. Hayden CK, Jr., Swischuk LE, Rytting JE. Gastric ulcer disease in infants: US findings. <i>Radiology.</i> 1987;164(1):131-134.	Observational-Dx	7 patients, 2 control groups; 20 patients each	To examine US findings in infants with gastric ulcer disease.	Findings are thickening of the mucosa (>4 mm) in the antropyloric region, elongation of the antropyloric canal, persistent spasm, and delayed gastric emptying. Two of the infants had slight thickening of the pyloric muscle. Gastrointestinal series or endoscopy demonstrated thickened gastric mucosa and a deformed gastric antrum in all infants, as well as actual ulceration in five.	3
18. Hernanz-Schulman M. Pyloric stenosis: role of imaging. <i>Pediatr Radiol</i> 2009; 39 Suppl 2:S134-139.	Review/Other-Dx	N/A	Review role of imaging in pyloric stenosis. Abdominal palpation, UGI and US are reviewed.	Abdominal palpation should be the first examination when pyloric stenosis is suspected, and if unsuccessful, should be followed by US if performed by experienced medical personnel. UGI can be done if accurate US is not available, or if reflux is the primary consideration.	4

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19. Rescorla FJ, Grosfeld JL. Contemporary management of meconium ileus. <i>World J Surg.</i> 1993;17(3):318-325.	Observational-Dx	60 neonates	To present findings and management of patients with early manifestations of cystic fibrosis.	35 neonates presented with 56 complications of meconium ileus, including volvulus (n = 22), atresia (n = 20), perforation (n = 6), and giant cystic meconium peritonitis (n = 8). Survival at 1-year was 92% in patients with uncomplicated meconium ileus and 89% for those with complicated meconium ileus. Therapy of choice for uncomplicated meconium ileus is nonoperative Gastrografin enema, with enterotomy and irrigation reserved for enema failures. Complicated cases require exploration and, in the absence of giant cystic meconium peritonitis, are usually amenable to bowel resection and primary anastomosis.	4
20. O'Keefe FN, Stansberry SD, Swischuk LE, Hayden CK, Jr. Antropyloric muscle thickness at US in infants: what is normal? <i>Radiology.</i> 1991;178(3):827-830..	Observational-Dx	145 consecutive patients: Group 1 (1-2 mm; 99 patients) Group 2 (\geq 3 mm; 40 patients), Group 3 (2 to <3 mm; 6 patients)	To determine normal antropyloric muscle thicknesses noted on US evaluation in infants presenting with chronic vomiting and/or regurgitation.	The final clinical diagnoses for all of the infants in the 3 groups confirmed the authors' initial impressions that antropyloric muscle thickness of <2 mm was anatomically normal, muscle measuring \geq 3 mm was abnormal and diagnostic for pyloric stenosis, and muscle from 2 to <3 mm was abnormal but not specifically diagnostic for pyloric stenosis. Patients with antropyloric muscle <2 mm thick should be considered unequivocally normal.	4
21. Rudolph CD, Mazur LJ, Liptak GS, et al. Guidelines for evaluation and treatment of gastroesophageal reflux in infants and children: recommendations of the North American Society for Pediatric Gastroenterology and Nutrition. <i>J Pediatr Gastroenterol Nutr.</i> 2001;32 Suppl 2:S1-31.	Review/Other-Dx	N/A	Guidelines for evaluation and treatment of GER in infants and children. Guidelines based on systematic review and expert opinion.	The guideline provides recommendations for management by the primary care provider, including evaluation, initial treatment, follow-up management and indications for consultation by a specialist. The guideline also provides recommendations for management by the pediatric gastroenterologist.	4

Vomiting in Infants Up to 3 Months of Age
EVIDENCE TABLE

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22. Vandenplas Y, Rudolph CD, Di Lorenzo C, et al. Pediatric gastroesophageal reflux clinical practice guidelines: joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN). <i>J Pediatr Gastroenterol Nutr.</i> 2009;49(4):498-547.	Review/Other-Dx	N/A	To develop a NASPGHAN and ESPGHAN international consensus on the diagnosis and management of GER and GER disease in the pediatric population.	More than 600 articles were reviewed for this work. The document provides evidence-based guidelines for the diagnosis and management of GER and GER disease in the pediatric population.	4
23. Seibert JJ, Byrne WJ, Euler AR, Latture T, Leach M, Campbell M. Gastroesophageal reflux--the acid test: scintigraphy or the pH probe? <i>AJR Am J Roentgenol.</i> 1983;140(6):1087-1090.	Observational-Dx	49 total: 41 infants and 8 children	Comparative study to determine accuracy of gastroesophageal scintigraphy and UGI in diagnosing GER in children.	Sensitivity of gastroesophageal scintigraphy, when compared to the 24-hour probe as a standard, was 79%; its specificity was 93%. Sensitivity of the UGI was 86%, when compared to the 24 hour pH probe test. However, its specificity was only 21%.	3
24. Villanueva-Meyer J, Swischuk LE, Cesani F, Ali SA, Briscoe E. Pediatric gastric emptying: value of right lateral and upright positioning. <i>J Nucl Med.</i> 1996;37(8):1356-1358.	Observational-Dx	48 children: (1 week to 2 year of age)	Delayed gastric emptying is assessed in the supine position to determine if emptying assessment is altered by changing position.	Percent of gastric emptying at 60 min in the supine position was 35% +/- 19%. After 90 min, in the right lateral decubitus, the percent gastric emptying was 60% +/- 25%. At 120 min, after an upright period, the gastric emptying was 73% +/- 20%. In the supine position 19/48 patients showed significant emptying (defined as >40% emptying). This increased to 41/48 normal studies considering the right lateral position and to 45/48 normal studies considering the infant upright position. Many patients with delayed gastric emptying show significant emptying just by changing position. Routinely complement gastric emptying studies with delayed views in the right lateral and upright position.	3
25. Yapici O, Basoglu T, Canbaz F, Sever A. The role of coughing as a gastroesophageal-reflux provoking maneuver: the scintigraphical evaluation. <i>Nucl Med Commun</i> 2009; 30(6):440-444.	Observational-Dx	125 patients	To examine the possible contribution of coughing as a provoking maneuver in GER scintigraphy.	61/125 patients (48.8%) showed no scintigraphic finding of GER and were interpreted as normal. In the remaining 64 patients (51.2%), GER was observed and these patients were interpreted as abnormal. 39% (25/64) of the observed GER findings were achieved exclusively by means of cough provocation.	3

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26. Orenstein SR, Klein HA, Rosenthal MS. Scintigraphy versus pH probe for quantification of pediatric gastroesophageal reflux: a study using concurrent multiplexed data and acid feedings. <i>J Nucl Med.</i> 1993;34(8):1228-1234.	Observational-Dx	12 scintigraphic and pH probe studies in 11 children	Comparative study to determine the ability of scintigraphic images in comparison to pH probe data to quantify GER in children and to identify an optimal scintigraphic framing interval.	Of the 64 reflux episodes detected by either method, scintigraphy detected 80%, the pH probe detected 63% and both methods concurrently detected 42%. Of the 681 60-sec images aggregated across patients, scintigraphy detected 55% of those with intraesophageal refluxate, the pH probe detected 96% and both tests concurrently detected 51%. A 1-hour scintigraphic study formatted in 60-second frames provides a quantitative representation of postprandial GER for children, particularly if they do not have rapid gastric emptying.	
27. Othman S. Gastroesophageal reflux studies using milk in infants and children--the need for multiple views. <i>Nucl Med Commun.</i> 2011;32(10):967-971.	Review/Other-Dx	105 patients	To assess the value of multiple acquisitions in detecting position-related GER.	After 2 hours of fasting, 11.4 MBq Tc-99m-sulfur colloid was given to the patient orally along with formula or milk (infants). Without sedation in most patients, serial images (30 s each for 15 frames=8 min) were acquired in the supine, prone, right-side down, and left-side down positions. If reflux was detected in one position, before proceeding to the next position the patient was given water or milk to clear the esophagus. The study was considered positive if the activity reappeared in the esophagus. Anterior and posterior chest images were obtained after a delay of 2-4 hours to detect any pulmonary aspiration. A total of 59 patients (56.2%) tested negatively for GER in all 4 positions and also showed a negative delayed scan for pulmonary aspiration. In contrast, 46 patients tested positively for GER in variable positions (prone=4, supine=6, left-side down=3, right-side down=12, and in more than one position=21, of which 6 included the supine position). The percentage yield of a positive GER position-related technique was three-fold that of conventional single supine position.	4

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28. Morigeri C, Bhattacharya A, Mukhopadhyay K, Narang A, Mittal BR. Radionuclide scintigraphy in the evaluation of gastroesophageal reflux in symptomatic and asymptomatic pre-term infants. <i>Eur J Nucl Med Mol Imaging</i> . 2008;35(9):1659-1665.	Observational-Dx	106 pre-term infants (52 symptomatic, 54 asymptomatic)	Radionuclide scintigraphy was used to evaluate the incidence of GER in symptomatic as well as asymptomatic pre-term neonates and to assess whether symptoms have any relation with positive scintigraphy.	Incidence of GER in the symptomatic group was 71.2% and in asymptomatic babies 61.1% (P= 0.275). High-grade reflux was more common (71.4%) than low-grade (28.6%) in both groups (P= 0.449). Mean number of reflux episodes in 20 min was 4.4 +/- 2.4 in symptomatic babies and 4.9 +/- 2.2 in asymptomatic babies (P=0.321). GER is common in pre-term infants of <34 weeks gestation. Positive scintigraphy has no correlation with symptoms.	3
29. Bowen A. The vomiting infant: recent advances and unsettled issues in imaging. <i>Radiol Clin North Am</i> 1988; 26(2):377-392.	Review/Other-Dx	N/A	Review issues that pertain to imaging of vomiting infants. Focus on: the use of newer low-osmolality, water-soluble contrast media in the infant's gastrointestinal tract; controversial subject of GER; and the burgeoning role of gastrointestinal US.	Many issues surrounding GER remain unsettled. The extended Ph probe test may become increasingly used with the availability of ambulatory home monitoring equipment. The UGI provides valuable anatomic detail and remains the most frequently used imaging exam. Author looks forward to further expansion of US role in bowel imaging.	
30. Heyman S, Eicher PS, Alavi A. Radionuclide studies of the upper gastrointestinal tract in children with feeding disorders. <i>J Nucl Med</i> . 1995;36(2):351-354.	Review/Other-Dx	1	To examine use of scintigraphy for evaluating infants with feeding disorders. Case of a female infant with a feeding disorder and with inadequate growth is described.	Scintigraphy should be used after imaging excludes an anatomic cause for vomiting in children with feeding disorders. Unusual for <3 months of age.	4
31. Argon M, Duygun U, Daglloz G, Omur O, Demir E, Aydogdu S. Relationship between gastric emptying and gastroesophageal reflux in infants and children. <i>Clin Nucl Med</i> 2006; 31(5):262-265.	Observational-Dx	108 patients aged between 3 months and 5 years (77 boys, 31 girls) Group A, 0-2 years (57 patients), and Group B, 2-5 years (51 patients)	To evaluate the relationship between gastric emptying and GER in infants and children. Patients were divided into 2 groups based on age range.	40/108 patients (37%) had GER findings on scintigraphy. The comparison of gastric emptying time between positive GER scintigraphy and negative GER scintigraphy groups was not statistically significant in any age group. No association was found between age and rate of gastric emptying time. Although the comparison of half emptying time (T1/2) between grade 1 patients and the GER-negative group was not statistically significant, grade 2 patients showed significant differences and had prolonged gastric emptying times. Results support delayed gastric emptying to be a pathogenetic factor in GER in infants and children.	3

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32. Cohen HL, Zinn HL, Haller JO, Homel PJ, Stoane JM. Ultrasonography of pylorospasm: findings may simulate hypertrophic pyloric stenosis. <i>J Ultrasound Med.</i> 1998;17(11):705-711.	Observational-Dx	71 total patients aged 10-126 days: 37 patients with HPS, 34 patients with pylorospasm	To compare US images and measurements of patients diagnosed as having HPS and pylorospasm among infants with projectile vomiting.	37 patients with HPS had an unchanged pyloric length (mean, 22.5 mm) and muscle wall thickness (mean, 5.3 mm). 34 pylorospasm patients had considerable variability in measurement or image appearance during their studies. Means of their longest or largest measurements were 14.4 mm for pylorus length and 3.8 mm for muscle wall thickness. Among these, 53% had muscle wall thickness of ≥ 4 mm and 18% had pyloric length of ≥ 18 mm during some portion of their study. Study concludes that pylorospasm may mimic HPS for at least a portion of a US study. Muscle wall thickness or pyloric length measurements may overlap those accepted as positive for HPS. Image or measurement variability is an important clue for diagnosing pylorospasm.	3
33. Haller JO, Cohen HL. Hypertrophic pyloric stenosis: diagnosis using US. <i>Radiology.</i> 1986;161(2):335-339.	Review/Other-Dx	N/A	Review of HPS and the current approach to diagnostic imaging in the vomiting infant.	US of the UGI tract is extremely operator dependent. It takes time and experience to become adept at making the proper diagnosis. US, when used carefully, can prove an excellent diagnostic tool for initial screening of the vomiting infant.	4
34. Hernanz-Schulman M, Sells LL, Ambrosino MM, Heller RM, Stein SM, Neblett WW, 3rd. Hypertrophic pyloric stenosis in the infant without a palpable olive: accuracy of sonographic diagnosis. <i>Radiology.</i> 1994;193(3):771-776.	Observational-Dx	152 consecutive infants	To evaluate the accuracy of US for both diagnosis and exclusion of pyloric stenosis in the infant with nonbilious vomiting without a palpable olive and to clarify the relationship between infant age and size and the dimensions of the hypertrophic pylorus.	Sensitivity, specificity, and accuracy of US in determination of appropriate surgical referral were 100%. US is highly sensitive and highly specific. It is the method of choice for both diagnosis and exclusion of pyloric stenosis.	3
35. St Peter SD, Holcomb GW, 3rd, Calkins CM, et al. Open versus laparoscopic pyloromyotomy for pyloric stenosis: a prospective, randomized trial. <i>Ann Surg.</i> 2006;244(3):363-370.	Experimental-Dx	200 total patients: 100 patients assigned to open and 100 patients assigned to laparoscopic pyloromyotomy	Prospective, randomized trial to compare open and laparoscopic pyloromyotomy for pyloric stenosis.	No difference in operating time or length of recovery between open and laparoscopic pyloromyotomy. However, the laparoscopic approach results in less postoperative pain and reduced postoperative emesis. In addition, there was a fewer number of complications in the laparoscopic group. Finally, patients approached laparoscopically will likely display superior cosmetic outcomes with long-term follow-up.	1

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36. Swischuk LE, Hayden CK, Jr., van Caillie BD. Mega-aeroesophagus in children: a sign of gastroesophageal reflux. <i>Radiology</i> . 1981;141(1):73-76.	Review/Other-Dx	47 infants and children (5weeks to 14 years)	To note significance of mega-aeroesophagus on radiographs.	Patients were grouped into three groups: those with chronic vomiting or regurgitation and no other disease (16 patients); those with chronic vomiting or regurgitation and cerebral palsy or mental retardation (24 patients); and miscellaneous group composed primarily of severely ill, near-moribund patients (8 patients). 35/47 patients were studied with an UGI, and 32 of these (94 %) demonstrated GER of a major degree, that is, free reflux into the upper two-thirds of the esophagus.	4
37. Di Ciaula A, Portincasa P, Di Terlizzi L, Paternostro D, Palasciano G. Ultrasonographic study of postcibal gastro-esophageal reflux and gastric emptying in infants with recurrent respiratory disease. <i>World J Gastroenterol</i> . 2005;11(46):7296-7301.	Observational-Dx	66 total infants (age range, 1-12 mo), 35 infants (13 with chronic cough, 22 with recurrent bronchitis) and 31 controls	To check the utility of postcibal US for the evaluation of reflux in relation to gastric emptying in infants with recurrent respiratory symptoms and to link imaging with clinical data.	Prevalence of abnormal (≥ 8 episodes) postcibal refluxes was 74% in patients and 3% in controls. Number, duration of the longest episode and extent of refluxes were significantly higher in patients compared to controls. Number of refluxes was higher in patients with symptomatic refluxes than in those without. Infants with recurrent bronchitis had more refluxes than those with chronic cough and controls. Extent and timing of gastric emptying were similar in patients and controls. Esophageal US is a useful and physiological test in infants with recurrent respiratory diseases, which have a high prevalence of abnormal postcibal esophageal reflux and a gastric emptying similar to that of normal controls. Esophageal reflux is more severe in subjects with recurrent bronchitis than in those with chronic cough.	2

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38. Blumhagen JD, Maclin L, Krauter D, Rosenbaum DM, Weinberger E. Sonographic diagnosis of hypertrophic pyloric stenosis. <i>AJR Am J Roentgenol.</i> 1988;150(6):1367-1370.	Observational-Dx	326 consecutive sonograms in 319 infants, 4 observers	To evaluate the accuracy of sonographic measurements for HPS. Observers retrospectively measured three parameters: 1) the thickness of the muscle in the wall of the gastric outlet, 2) the length of that muscle, and 3) the length of the pyloric channel.	In the patients with HPS, muscle thickness was 4.8 +/- 0.6 mm, muscle length was 2.1 +/- 0.3 cm, and channel length was 1.8 +/- 0.3 cm. In the patients without HPS, muscle thickness was 1.8 +/- 0.4 mm, muscle length was 1.3 +/- 0.3 cm, and channel length was 1.1 +/- 0.3 cm. The mean measurement for each parameter was significantly larger in patients who had HPS than in those who did not (P<.01). However, histograms of the three parameters show significant overlap in the measurements of muscle length and channel length between the patients with and those without HPS. The thickness of the muscle is the most discriminating and accurate criterion for HPS.	2
39. Forster N, Haddad RL, Choroomi S, Dilley AV, Pereira J. Use of ultrasound in 187 infants with suspected infantile hypertrophic pyloric stenosis. <i>Australas Radiol.</i> 2007;51(6):560-563.	Observational-Dx	187 infants	Retrospective review to evaluate the diagnostic efficacy of US in the diagnosis of infantile HPS.	Sensitivity and specificity of pyloric muscle thickness was 91% and 85%, respectively, and of pyloric muscle length 76% and 85%, respectively. US criteria for a positive diagnosis were pyloric muscle thickness ≥ 3 mm and pyloric muscle length ≥ 17 mm. The ability of US to diagnose infantile HPS using the criteria was significant (t-value, pyloric muscle thickness 14.93 and pyloric muscle length 6.89; P<0.0001). There was no significant correlation between age, weight or prematurity and a US diagnosis of infantile HPS (Pearson's coefficient <0.3). Therefore, the same US criteria should apply irrespective of prematurity, age or weight. Borderline pyloric muscle thickness and pyloric muscle length measurements necessitate repeat US or alternative imaging.	4
40. Cohen HL, Blumer SL, Zucconi WB. The sonographic double-track sign: not pathognomonic for hypertrophic pyloric stenosis; can be seen in pylorospasm. <i>J Ultrasound Med.</i> 2004;23(5):641-646.	Observational-Dx	91 consecutive patients	To study US findings in patients with projectile vomiting, in particular the double track sign. Data obtained prospectively from patients by US for projectile vomiting were retrospectively reviewed.	37 patients had a US diagnosis of HPS that was confirmed surgically. 26 (70.2%) showed a US double-track sign. 34 patients had a US diagnosis of pylorospasm that was confirmed by close clinical follow-up. 18 (52.9%) showed a US double-track sign. US double-track sign can be seen in cases of pylorospasm as well as HPS. It is not pathognomonic for HPS.	3

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EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
41. Foley LC, Slovis TL, Campbell JB, Strain JD, Harvey LA, Luckey DW. Evaluation of the vomiting infant. <i>Am J Dis Child</i> . 1989;143(6):660-661.	Review/Other-Dx	112 total patients between ages 1 to 8 weeks 37 patients HPS, 46 patients GER without another abnormality, 13 patients abnormalities other than GER or HPS, 16 patients normal examination findings	Prospective study to evaluate the cost, risk, and benefit of US followed by UGI for the evaluation of the infant who vomits.	33% reduction in UGI performed, 95% increase in cost. Use of US for the initial evaluation of vomiting in infants substantially increases the cost with no meaningful decrease in morbidity and mortality.	4
42. Forman HP, Leonidas JC, Kronfeld GD. A rational approach to the diagnosis of hypertrophic pyloric stenosis: do the results match the claims? <i>J Pediatr Surg</i> . 1990;25(2):262-266.	Observational-Dx	101 total infants	To test premise that HPS should be diagnosed clinically with US and UGI reserved for negative physical exam.	Physical exam is 77% sensitive for diagnosing HPS and no imaging necessary. A definitely palpable pyloric mass had a predictive value of 100% but the absence of a definitely palpable mass still had a 44% chance of HPS. The benefits of a "US first" approach are less apparent but no less important and increase as clinical experience declines and performance of US improves.	3
43. Olson AD, Hernandez R, Hirschl RB. The role of ultrasonography in the diagnosis of pyloric stenosis: a decision analysis. <i>J Pediatr Surg</i> . 1998;33(5):676-681.	Review/Other-Dx	N/A	Decision analysis techniques to determine if US as initial screen in vomiting infants is cost effective when compared to UGI only. Compared UGI alone and US followed by UGI in 50% of cases when US negative for pyloric stenosis.	UGI as the initial study is the most cost-effective radiological diagnostic test in the evaluation of the vomiting infant.	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
 - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
 - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
 - c) the study is an expert opinion or consensus document.

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

CT = Computed tomography

GER = Gastroesophageal reflux

HPS = Hypertrophic pyloric stenosis

NPV = Negative predictive value

MRI = Magnetic resonance imaging

PPV = Positive predictive value

SMA = Superior mesenteric artery

SMV = Superior mesenteric vein

UGI = Upper gastrointestinal

US = Ultrasound